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Final Report

R-87-01-0229

Protein and Energy Requirements for Feedlot Cattle

Conducted by
J. McKinnon and Dr. R. Cohen

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EXECUTIVE SUMMARY

PROJECT NAME: PROTEIN AND ENERGY REQUIREMENTS FOR FEEDLOT CATTLE

PROJECT NUMBER: R-87-01-0229

SUBMITTED TO: AGRICULTURE DEVELOPMENT FUND
SASKATCHEWAN AGRICULTURE AND FOOD

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Abstract

A series of feeding trials were conducted to determine the energy and protein requirements of large frame steers fed as weaned calves or as backgrounded yearlings. Feeding higher energy and protein levels, particularly on low energy rations increased live and carcass gain. However, calves fed higher protein levels exhibited reduced rates of carcass lean gain and increased rates of fat gain. Bypass protein did not benefit performance or economic return. It is concluded that feedlot operators should formulate diets for large frame steers according to current crude protein recommendations. For efficient gains, diets formulated to 78.5% TDN or its equivalent are required at or shortly after weaning.

Summary

A series of feeding trials were conducted to determine the dietary energy and protein requirements of large frame feedlot cattle managed under Saskatchewan feeding conditions. Trials 1 and 2 examined the influence of increasing energy and protein concentration on feedlot performance and carcass quality of large frame steers which had been fed as calves from weaning or backgrounded over the winter prior to placement in the feedlot as yearlings. Trials 3 and 4 examined the influence of bypass protein on the feedlot performance and carcass characteristics of large frame steers placed directly in the feedlot following weaning.

Calves placed in the feedlot following weaning exhibited higher rates of live animal and carcass weight gain when fed high energy rations. Daily carcass fat gain however, was increased by the high energy rations. Animals fed low energy rations exhibited several indices of higher carcass lean content including larger ribeye areas and higher cutability scores. Yearling steers did not show any influence of energy level on carcass gain or composition.

The calves also gained significantly faster when fed higher crude protein levels. Animals fed 16, 17 or 19% crude protein had higher daily live weight gains than those fed the 11% control ration. Calves fed 16% protein exhibited higher rates of carcass fat deposition than the control animals. Within energy levels, both calves and yearlings when fed the low energy rations, exhibited an increase in live weight and carcass gain as dietary crude protein level increased. However, calves on low energy rations had reduced rates of carcass lean gain and tended to have higher rates of carcass fat deposition when fed higher levels of crude protein.

Trial 3 demonstrated that heat but not chemical treatment can increase the bypass protein content of canola meal. Based upon the increase in bypass protein content and chemical properties of the meal, it was determined that heating to 125 ° C for 20 minutes would provide an acceptable bypass protein supplement for feedlot cattle. However, averaged over the entire feeding period, large frame steer calves showed no improvement in performance or in any measured carcass trait when fed a range of bypass protein from 22 to 34%. Calves fed 28% bypass protein did however, show an increase in weight gain at day 56 of the trial compared to those fed 22%.

It is concluded that the improved growth response seen with large frame steers fed higher than recommended crude protein levels is due to utilization of dietary protein as a supplemental energy source. Due to the cost of protein supplementation, particularly in relation to supplemental energy sources and the reduced carcass quality seen with feeding higher levels of protein, it is recommended that feedlot operators formulate diets to current recommended crude protein levels (NAS-NRC 1984), unless specific environmental conditions warrant otherwise. Should the aim of the feeding program be to maximize gains, improve on the efficiency of production and reduce time in the lot, the results of this study

show that large frame calves should be placed on rations containing 78.5 % TDN or its equivalent at or shortly after weaning.

Appendix:

(C) TALKS AND PAPERS PRESENTED:

(i) Talks

1987 - Beef meetings at Baldwinton Nipawin, Porcupine Plains and Lloydminister, Sk.
- Feedlot school, Saskatoon, Sk.

1988 - Beef meetings at Vermillion and Lethbridge Ab.
- Saskatchewan Agriculture staff meeting, Saskatoon
- Agribition, Regina, Sask.
- Lecture on Feedlot Nutrition to Fourth Year Animal Science
- Agriculture Institute of Canada Calgary, AB.
-Feedlot school, Saskatoon, Sk.

1989 - Beef Meeting, Turo, NS.
- Feedlot school, Charlottetown, NS.
- University of Saskatchewan beef field day, Termunde Research STn.
- Lecture on Feedlot Nutrition to Fourth Year Animal Science

1990 - Beef Field Day, Spirtwood, Sk.
- Agriculture Institute of Canada meeting, Pentiction, BC.

(ii) Papers - Diets For Big Steers. (1987). Cattleman's December issue.

Balancing Frame Size and Protein. (1989). Saskatchewan Cattlefeeders Newsletter.

Balancing Frame Size and Protein. (1989). Canola Council Newsletter For Alberta Cattlefeeders meeting.

Dietary Energy and Protein Requirements of Cattle That Differ in Mature Body Size. (1989). Termunde Research Station Beef Report, University of Saskatchewan.

Dietary Energy and Protein Requirements of Cattle That Differ in Mature Body Size. (1989). University of Saskatchewan Research Reports.

Protein Requirements of Large Frame Steers (1990). Can. J. An. Sci. (Abstract in press).

Dietary Energy and Protein Requirements of Large Frame Steers. (1990). Termunde Research Station Beef Report, University of Saskatchewan (in press).

(d) See University of Saskatchewan Research Accounts report.

(e) Personnel involved - Research Technician Ms. T. Vigor (100 % of time with project).

- Research Associate John McKinnon (100% of time)

(f) No equipment over $500.00 was purchased.

FINAL REPORT

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Abstract

A series of feeding trials were conducted to determine the energy and protein requirements of large frame steers fed as weaned calves or as backgrounded yearlings. Feeding higher energy to calves and higher protein levels to both calves and yearlings, particularly on low energy rations increased average daily live weight and carcass gain ($P<0.05$). However, calves fed higher protein levels exhibited reduced rates of carcass lean gain and tended to show an increased rate of carcass fat gain ($P<0.05$). Bypass protein did not benefit performance. In general, the improved gains seen with higher protein rations did not offset the cost of protein supplementation. It is concluded that feedlot operators formulating diets for fast efficient gains, should follow current recommended crude protein guidelines and consider placing large frame steers on the equivalent of 78.5% TDN at or shortly after weaning as dictated by frame development.

I BACKGROUND AND OBJECTIVES:

In the fall of 1986 the Department of Animal and Poultry Science of the University of Saskatchewan, funded by the Saskatchewan Agriculture Research Fund (SARF) of Saskatchewan Agriculture and Food, initiated a study aimed at evaluating the energy and protein requirements of medium and large frame feedlot cattle (McKinnon and Cohen 1989 SARF Final Report). This work provided strong evidence that for maximum growth, large frame steer calves required dietary crude protein levels in excess of those currently recommended by the National Academy of Science-National Research Council (NAS-NRC) (1984). This work has important implications for Saskatchewan and western Canadian feedlot operators as there is an ever increasing number of large frame feeder cattle entering feedlots for finishing. However, due to its limited nature, several important questions were left unanswered. These included:

- what are the precise energy and protein requirements of large frame steers fed for maximum growth rates?

- do protein and energy requirements vary for large frame cattle that are raised under varying production situations in current practice?

A third question that arose out of this initial study was:

- if such cattle respond to increased levels of dietary crude protein, what are the benefits of feeding bypass protein?

Bypass protein is protein of dietary origin that passes through the rumen or forestomach undigested and enters the stomach and small intestine where it becomes available for digestion and utilization by the animal. Studies have shown that with certain classes of ruminants managed for high production, performance can be improved by feeding higher levels of bypass protein. However, most feedstuffs commonly utilized by feedlot operators are relatively poor sources of bypass protein. This makes it extremely difficult to formulate diets to specific levels of bypass protein without the use of cost prohibitive supplements such as fish meal or dehydrated alfalfa. It would thus be of considerable interest to cattle feeders and the feed industry if work could be undertaken to develop a bypass protein source that could be grown, processed and purchased in western Canada at competitive prices.

Answers to these questions are required if cattle-feeders and industry nutritionists are to accurately formulate diets that allow for efficient and profitable gains. The objectives of this research were therefore:

1) To define the energy and crude protein requirements of large frame feeder steers managed under western Canadian feeding conditions, with respect to optimizing feedlot performance, carcass composition, meat quality and profit potential.

2) To evaluate the role that bypass protein plays in supplying the total protein requirements of rapidly growing large frame steer calves.

In order to meet these objectives, a series of feeding trials were conducted. The specific objectives of these trials were:

Trial 1 - To examine the influence of increasing dietary energy and crude protein concentration on feedlot performance of large frame steer calves placed directly in the feedlot following weaning.

Trial 2 - To examine the influence of increasing dietary energy and crude protein concentration on feedlot performance of large frame yearling steers which had been backgrounded over the winter, prior to placement in the feedlot.

Trial 3 - In order to obtain a readily available source of bypass protein for a proposed feeding trial, a study was undertaken to investigate the influence of heat and chemical treatment on the bypass protein value of canola meal.

Trial 4 - To examine the influence of crude protein and bypass protein level on feedlot performance and carcass characteristics of large frame steer calves.

II EXPERIMENTAL METHODS:

Animals and Management Regime:

Trial 1 and 2: In the fall of 1987, approximately 500 large frame steer calves were purchased from selected feeder cattle sales throughout rural Saskatchewan and sorted into two management groups. Group 1 was assigned directly to the feedlot following weaning (December, 1987), while group 2 was assigned to a backgrounding program which allowed the animals to grow at a reduced rate of gain over the winter, prior to placement in the feedlot. All animals were fed during the feedlot finishing phase at the Beef Research Unit of the Department of Animal and Poultry Science of the University of Saskatchewan. Group 2 calves were backgrounded at the University of Saskatchewan Termuende Research Station, located at Lanigan, Saskatchewan. The finishing phase for group 2 animals took placed over the summer of 1988 (May to October).

Trial 3: One rumen fistulated steer was utilized to determine dry matter and crude protein bypass values of untreated and treated canola meal.

Trial 4: In the fall of 1888, approximately 300 large frame steer calves were purchased from similar sources to those in 1987. These animals were assigned directly to the University feedlot for finishing.

III Methodology and Treatment Protocol:

Trial 1:

In the fall of 1987, two hundred and twenty six large frame Charolais cross steer calves were randomly assigned to 24 pens. Each pen was randomly assigned to one of 12 finishing rations formulated to contain one of 2 energy levels (73.5 and 78.5% TDN) and one of six crude protein levels (11, 13, 15, 16, 17 and 19%). The feedlot finishing period took place from December, 1987 to May, 1988.

Data collection included: biweekly weight gain and pen feed consumption, frame size, average daily gain, days to market and feed efficiency. At the completion of the trial, carcasses were evaluated for warm weight, fat cover, ribeye area, marbling score, dressing percentage and cutability.

Carcass composition was determined utilizing a slaughter and dissection procedure. Initial carcass composition was determined

by the slaughter and dissection of ten randomly selected animals prior to the start of the experiment. Carcass composition at slaughter (% lean, % fat and % bone) was determined through the dissection of eight-bone rib sections collected from 96 animals (four per pen). These were dissected into muscle, fat and bone. The results of the rib dissections were extrapolated to the whole carcass based on the following regression equations (S.D.M. Jones personnel communication 1988):

$$\% \text{ carcass lean} = 17.223 + 0.797 \ (\% \text{ rib lean})$$
$$r^2 = 0.80 \quad RSD = 1.73\%$$

$$\% \text{ carcass fat} = 3.00 + 0.76 \ (\% \text{ rib fat})$$
$$r^2 = 0.84 \quad RSD = 1.71\%$$

$$\% \text{ carcass bone} = 100 - (\% \text{ carcass lean} + \% \text{ carcass fat})$$

Based on the results of the slaughter and dissection procedure, the following measurements were recorded: initial carcass lean, fat and bone content; final carcass lean, fat and bone content; total carcass lean, fat and bone gain; average daily carcass lean, fat and bone gain.

The experiment was designed as a 2 (two levels of energy) x 6 (six levels of crude protein) factorial, with a pen of 9 animals representing the experimental unit. The experiment was analyzed using the analysis of variance for a factorial design. Mean separation was achieved using Student-Newman Keul's procedure. Regression was used to analyze the response of weight gain, feed intake, etc., to increasing crude protein level, within each energy level of the diet.

Trial 2:

Two hundred and two large frame steer calves were overwintered (November/87 - May/88) on a growing ration designed to allow 0.5 kg/day gain. At the completion of the backgrounding period, animals were assigned to one of 24 pens and fed the same 12 finishing rations as in trial 1.

Experimental design and data collection were similar to that described for trial 1. To estimate body composition at the end of the backgrounding period, a further eight randomly selected animals were slaughtered and dissected at this stage. The data were analyzed using the same statistical methods described for trial 1.

Trial 3:

In order to obtain a readily available source of bypass protein for a proposed feeding trial, a preliminary investigation was undertaken to determine the influence of chemical and heat treatment on the bypass protein content of canola meal. Chemical treatments included formic and acetic acids applied at the rate of 3% volume by weight. Heat treatment included 125 and 145 degrees

C for 10, 20 and 30 minutes. Samples were subsequently incubated in a rumen fistulated steer for 12 hours using the nylon bag procedure. Undigested material was analyzed for dry matter and crude protein content with residual weights used to calculate bypass protein level.

Trial 4:

Based on the results of trial 3, a feeding trial was designed to examine the influence of dietary crude protein level and bypass protein content on the performance of large frame feedlot steers. Two hundred and sixty four Charolais cross steer calves were randomly assigned to 24 pens. Each pen was fed one of eight diets, formulated to one of two crude protein levels (13 and 16%) and one of four bypass protein levels (22, 28, 32 and 34 %). Bypass protein levels of dietary ingredients were based on book values (Preston 1988). Dietary energy level was held constant at 73.5 % TDN. Rations were based on barley silage and barley grain. To alter the level of bypass protein, four protein supplements were utilized. These included urea, canola meal, heated canola meal and corn gluten meal. The trial was initiated on Dec 21, 1988 and ran through June 21, 1989. The experiment was designed as a 2 (two levels of crude protein) X 4 (four levels of bypass protein) factorial with the pen of 11 animals representing the experimental unit. Data collection included average daily gain, pen feed consumption and efficiency, days on feed and carcass characteristics such as weight, fat cover, marbling and ribeye area.

IV Results and Discussion

Since the objectives of this project were to define the protein and energy requirements of large frame steers, the results of the three feeding trials will be presented prior to a discussion of their significance.

Results:

Trial 1 and 2:

Trial 1 and 2 examined the response of large frame feedlot steers managed under two different systems to diets that varied in energy (73.5 and 78.5% TDN) and crude protein content (11, 13, 15, 16, 17 and 19%). A description of the diets and their nutrient content are presented in table 1. The low energy, low protein diet was formulated to meet the energy and protein requirements of a large frame 280 kg steer fed to gain 1.36 kg per day as recommended by the National Academy of Science - National Research Council (1978) (NAS-NRC 1978). The high energy, low protein diet was formulated to meet the requirements of a large frame 280 kg steer

gaining 1.59 kg per day (NAS-NRC 1978). Similar nutrient levels were utilized for the finishing phase of group 2 animals in order to provide a comparison of the nutrient requirements for feedlot growth of animals managed under two different systems. The crude protein levels utilized in the study were based on the results of previous work in this department (Mckinnon and Cohen 1987 SARF Final Report) which showed a beneficial growth response to increased dietary crude protein with large frame steers fed in a similar manner. Variation in dietary energy level was achieved through manipulation of the silage to concentrate ratio (Table 1), while crude protein levels were altered via supplementation of canola meal (Table 2).

In trial 1, large frame calves placed directly on finishing rations demonstrated a beneficial growth response to both increasing energy and protein concentration of the diet (Table 3). Animals fed high energy diets gained faster (0.15 kg per day) ($P < 0.05$) and spent less time on feed (15 days) ($P < 0.05$) than those fed the low energy diets. This improvement in performance resulted in more efficient gains ($P < 0.05$) for those animals fed the high energy rations. Similarly, feedlot performance improved as crude protein level increased. In particular, weaned calves fed 16, 17 or 19% crude protein had higher rates of gain than those fed 11% crude protein ($P < 0.05$). At 16% crude protein the magnitude of this increase was 0.19 kg per day (Table 3). Regression analysis indicates that the response to dietary crude protein varies depending on the energy level of the diet (Figure 1). Calves fed low energy diets demonstrated a significant linear improvement in growth as dietary crude protein level increased ($r^2 = 0.75$; $P < 0.001$), while those fed high energy diets exhibited similar gains regardless of dietary crude protein level (Figure 1). Other performance parameters such as time in the feedlot or efficiency of gain were not significantly influenced by treatment although those animals fed 16% crude protein tended to show an improvement in performance when compared to the control animals.

Carcass characteristics of large frame steers placed directly in the feedlot following weaning were not influenced by crude protein level of the diet, but did show some influence of dietary energy concentration (Table 4). Ribeye area and carcass cutability were increased when the low energy diets were fed ($P < 0.05$), while grade fat was reduced ($P < 0.05$). Marling score was reduced with low energy feeding, indicating increased intramuscular fat deposition. Carcass composition and the influence of treatment on daily carcass gain are presented in table 5. While there were no differences in final carcass composition, average daily carcass gain and the components of that gain showed an influence of both energy and protein supplementation. In particular, calves fed high energy rations had higher daily carcass weight and fat gains than those fed low energy diets ($P < 0.05$), while those fed 16% crude protein gained 0.10 kg per day more carcass fat than those fed the 11% control ration ($P < 0.05$) (Table 5). As with average daily live weight gain, the influence of dietary protein level on daily carcass gain varied depending on dietary energy level (Figure 3 and

4). When low energy rations were fed, daily carcass gain increased linearly with increasing crude protein level of the diet (r^2 = 0.73; P < 0.001) (Figure 3). Daily carcass fat gain also increased with increasing dietary crude protein level, although the increase was not as great as with daily carcass weight gain (r^2 = 0.36; P < 0.04). In contrast, daily carcass lean gain showed a quadratic response to increasing dietary crude protein level of the diet (r^2 = 0.62; P < 0.02) (Figure 3). This quadratic effect implies that carcass lean gain decreased at each succeeding level of crude protein up to 16%, and then tended to plateau and gradually increase as dietary crude protein increased further. Calves fed high energy rations showed little influence of protein level on any aspect of carcass gain. The one exception was a weak quadratic effect where daily fat gain on low energy rations increased as dietary crude protein level increased to 16% (r^2 = 0.36; P < 0.06) (Figure 4), similar to that seen with the calves on low energy rations.

In contrast to the calves, the backgrounded yearling steers in trial 2 did not respond favourably to either increasing energy or protein level (Table 6). When each energy level is examined separately however, it can be seen that the backgrounded steers responded to protein supplementation in a similar manner to the calves (Figure 2). Animals fed low energy rations demonstrated a linear increase in growth as dietary crude protein level increased (r^2 = 0.57; P < .03) while as with the calves, the animals fed the high energy rations had similar gains regardless of protein level fed (Figure 2). It is important to note however, that while the response curves to protein supplementation were similar in shape for both the calves and the backgrounded yearlings, the improvement seen on low energy diets was greater in trial 1 with the calves. This is evident when one considers the slope and regression coefficients for each low energy regression line (slope = 0.042 r^2 = 0.75 and slope = 0.03 and r^2 = 0.57 for the calves and yearlings respectively). Furthermore, in contrast to the calves there was no significant effect of dietary energy or protein level on carcass characteristics (Table 7) or on carcass component gain (Table 8) other than a linear increase in carcass weight gain with increasing crude protein content of the diet (r^2 = 0.73; P < 0.001) when low energy rations were fed.

Trial 3 and 4

Trial 3 was designed to evaluate the influence of heat and chemical treatment on the bypass protein value of canola meal. Table 9 shows that both the temperature and duration of heating increased the bypass protein value of canola meal (P < 0.05). At 12 hours of incubation, the bypass protein value of canola meal was 40.4 %. When heated at 125°C for 10, 20 or 30 minutes, respective bypass values were 72.3, 77.9 and 77.3 %. Respective values at 145°C were 85.9, 84.3 and 85.6 %. Treatment with acetic or formic acid did not influence rumen protein degradability. Table 1, also shows that heat treatment increased the acid detergent

insoluble nitrogen (ADIN) content of canola meal, particularly at 145°C. Acid detergent insoluble nitrogen is used as a measure of heat damaged protein that is unavailable to the animal.

The silage and concentrate ratios and chemical analysis of experimental rations used in trial 4 are presented in table 10. The bypass protein levels were based on studies with other classes of ruminants, and represent a range which should ensure a growth response, if bypass protein is required with this class of ruminant. Specific bypass protein levels were achieved by manipulating the level of 4 protein supplements. These included urea, canola meal, heated canola meal and corn gluten meal (Table 11).

The results of this trial show that increasing the level of bypass protein in the diets of large frame feedlot steers has little influence on their performance. Standard performance parameters such as average daily gain, days on feed or feed efficiency were not affected by bypass protein level (Table 12). Similarly, no influence of treatment was seen on any measured carcass parameter (Table 13). The only beneficial response to bypass protein was observed at day 56 of the trial. Animals fed 28% bypass protein gained significantly faster than those fed 22% bypass protein. It is important to note however, that the 28 % bypass protein level was achieved by formulating diets without the inclusion of a supplemental bypass protein source (Table 11). Consistent with the results of trial 1, large frame steers fed 16% crude protein gained significantly faster than those fed 13% crude protein (Table 12).

Discussion:

It is evident from this study and from previous work in this department that both dietary energy and crude protein level influences the growth of large frame feedlot cattle. The greatest effect of dietary energy level was seen with the calves placed directly on feed. Calves fed the 78.5 % TDN ration had greater rates of gain and spent an average of 15 days less in the feedlot. On the other hand, calves fed the 73.5 % TDN ration yielded carcasses with greater ribeye area and higher cutability. Both of these measures are indicators of lean meat yield and indicate that calves fed the low energy rations produced carcasses with increased lean content. Improvement in carcass cutability likely results from reduced growth rates and a longer time on feed. Such a feeding regime would allow for maximum lean growth prior to the onset of fat deposition.

In contrast to the calves, the backgrounded yearling steers in trial 2 did not respond favourably to the high energy diet. This is somewhat surprising, since if consumed at equal dry matter intakes, the high energy ration would have supplied about 6.4 % more TDN. According to NAS-NRC (1984) this should allow for an extra 0.23 kg of gain per day. Backgrounded large frame yearling steers gained 0.1 kg more per day than those fed low energy rations but the difference was not statistically significant. However,

backgrounded yearlings fed the low energy rations consumed approximately 2.5 % more dry matter than those fed high energy rations. This extra intake would have reduced the energy difference between the two rations by about 38% which would account for the lack of an expected difference in gains between the two energy levels.

The improvement in growth which occurred when steers were fed crude protein levels in excess of those currently recommended by the NAS-NRC (1984) is similar to that seen in our previous work. These results indicate that for maximum growth rates, current recommendations under-estimate the protein requirements of large frame feedlot cattle. However, it is also evident from this work that the response to increased dietary protein concentration is influenced by energy level of the diet and by management factors such as backgrounding which influence the age of the animal entering the feedlot. For instance, backgrounded yearling steers showed very little response to increasing dietary crude protein concentration. On the other hand, calves placed directly on feed gained significantly faster when fed 16, 17 or 19 % crude protein compared to those fed the 11 % control ration. This influence of management level and age can be attributed to differences in physiological maturity. Yearling cattle are physiologically more mature than calves placed directly on feed. Differences in physiological maturity would result in differences in the composition of gain, with calves depositing a greater proportion of lean tissue (respective values 54.8 vs 52.3 %) but proportionally less fat than yearlings (respective values 34.9 vs 36.5 %). Thus it is not entirely unexpected that yearling cattle fail to show a beneficial response to increased levels of crude protein. A confounding factor is that the yearling steers appeared to exhibit compensatory gain early in the feeding period. For example at day 28 of the trial, calves placed directly in the feedlot averaged 1.21 kg per day daily gain, while yearling steers averaged 1.47 kg per day. The above average gains exhibited early in the trial may have masked the influence of dietary treatment. However, the lack of a beneficial response to protein supplementation during this phase would indicate that the crude protein requirement (as a % of ration dry matter) is not increased during this type of rapid compensatory growth.

Dietary energy level also played an important role in mediating the response of large frame steers to increasing levels of dietary protein. When fed low energy rations both the calves and the yearlings showed an increase in average daily live- weight and carcass gain as crude protein level of the ration increased. However, no benefits of dietary crude protein level were seen on the high energy rations. These conflicting results would suggest that the improvement in gain seen with higher protein levels on low energy rations is due to utilization of the protein as a supplemental energy source. This conclusion is supported by two lines of evidence. First, both daily gain and carcass gain in calves and yearlings increased linearly with increasing dietary crude protein when fed low energy rations (Figure 1 & 2). If the

supplemental protein was in fact meeting a deficiency in the animal's amino acid requirements, it would be expected that the improvement in gain would be observed for both dietary energy levels. Secondly, daily lean carcass gain would be expected to increase as daily carcass gain improves, if the supplemental crude protein was being used for protein needs. In fact, as daily carcass gain of calves fed low energy rations increased with increasing dietary crude protein level, daily carcass lean gain decreased in a quadratic manner, bottoming out at 16% crude protein (Figure 3). Daily carcass fat gain on the other hand, tended to increase in a linear nature, as crude protein level of the diet increased (Figure 3).

An alternative hypothesis to account for the improvement in performance seen with increasing dietary crude protein level, particularly when fed in combination with low energy, is that as dietary crude protein increases, ration digestibility increases, thereby providing an increased energy supply to the animal. Previous work in this department has shown that as dietary crude protein level of the ration increased from 11 to 13 to 15%, digestible energy content of the ration increased at each protein level when low energy rations were fed but plateaued at 13% crude protein on high energy rations. Such an improvement in ration digestibility may result from an improved rumen environment for microbial digestion of the ration when higher levels of dietary protein are fed.

Regardless of the mechanism, the results of this work strongly suggest that supplemental crude protein over and above that currently recommended for large frame feedlot cattle is not being used to meet an animo acid deficit, rather it is being diverted into the animal's energy metabolism. This would explain why the improved growth response is mainly in the form of fat. In an effort to modify the composition of carcass gain yet maintain the improvement in live weight gain seen with supplemental protein on low energy rations, trial 4 attempted to vary the quantity and possibly quality of amino acids available to the animal by feeding supplemental bypass protein. Canola meal heated at 125 $^{\circ}$ C for 20 minutes was utilized as a source of bypass protein along with regular canola meal, urea and corn gluten meal. The temperature and duration of heating was based upon the increase in bypass protein content compared to the untreated meal. Heating at this level increased the bypass protein content by 37.5%. Furthermore, acid detergent insoluble nitrogen, a measure of heat damaged unavailable protein, was only marginally increased at this temperature and duration of heating. Therefore, the intestinal availability of canola meal treated at this temperature would not be expected to be reduced to any great extent.

In terms of feedlot performance, daily gain was improved early in the feeding period by feeding 28% bypass when compared to the 22 % level but not by higher levels. Such a response to bypass protein early in the feeding period has been observed in other studies and may result from a more balanced supply of protein matching the animal's amino acid requirements. However, this

response was not in evidence further into the feeding period and no influence of bypass protein level on gains or carcass parameters was observed at slaughter. There was however, a significant improvement in daily live weight gain with animals fed 16% crude protein compared to those fed 13%. The failure to see any improvement in carcass measurements such as ribeye area or cutability would again suggest that the supplemental crude protein is not being used to meet amino acid requirements but is being diverted to meet the animal's energy needs and in particular that for fat deposition.

Feedlot performance, particularly that of large frame calves fed 73.5 % TDN from weaning has been shown to be improved by dietary crude protein levels in excess of that currently recommended by the NAS-NRC (1984). Although the quality of the carcass has been shown to be adversely affected by feeding higher protein levels, cattlemen may decide to formulate diets to higher levels of crude protein if a net return is realized. Table 14 compares the cost of substituting canola meal for silage and barley in the rations of calves fed low energy rations from weaning. Based on ration composition and live animal value, the 13 and 16% rations returned $5.20 and $10.33 per head respectively, over the cost of protein supplementation. All other crude protein levels, including all on the high energy rations and those fed to the yearling cattle, would result in negative returns compared to the control. While the economic return to higher protein levels would vary depending on the cost of protein supplementation and the value of the finished animal, it is unlikely that the improved feedlot performance seen with higher levels of crude protein would outweigh the reduction in carcass quality and increased cost of feeding. In fact, if the supplemental crude protein is actually being used metabolically to meet energy needs, feedlot operators would be well advised to supplement energy directly and thereby reduce feeding costs.

V Conclusion and Impact

In conclusion, the results of this project show that large frame feedlot steers when fed from weaning exhibit greater weight gains, improved feed efficiencies and spend less time in the feedlot when fed 78.5% TDN. Feeding dietary crude protein levels in excess of those currently recommended by the NAS-NRC (1984) also resulted in superior feedlot performance. Maximum weight gains were observed at 16% crude protein. The response to crude protein however, was modified by management factors such as backgrounding and dietary energy level. Feeding higher levels of crude protein did not influence other performance parameters such as days on feed, feed consumption or feed conversion efficiency. Carcass composition was however, adversely affected by feeding 16% crude protein to calves on low energy rations. Furthermore, in this study the increased cost of feeding associated with higher levels of crude protein, were not offset by improved financial returns with

the exception of the 13 and 16% levels fed to calves on low energy rations. Higher protein costs and or lower slaughter values would further reduce the economic return to higher levels of crude protein. Bypass protein levels in excess of those commonly achieved in feedlot diets do not appear to benefit the performance of feedlot steers when the entire feeding period is considered. No economic benefits were seen from feeding higher bypass protein levels.

In view of the fact that carcass composition and meat quality were adversely affected as dietary crude protein level increased and that the improved performance was insufficient to provide a reasonable return to protein supplementation, it would seem unwise for feedlot operators formulating diets for large frame steers to exceed the recommendations of the NAS-NRC (1984), unless specific environmental conditions call for modifications to the animal's requirements. If however, the objectives of the feeding program are to maximize gain and feed efficiency as well as reduce the amount of time on feed, feedlot operators should consider placing large frame calves directly on rations containing 78.5 % TDN, at or shortly after weaning when these animals have obtained adequate frame development.

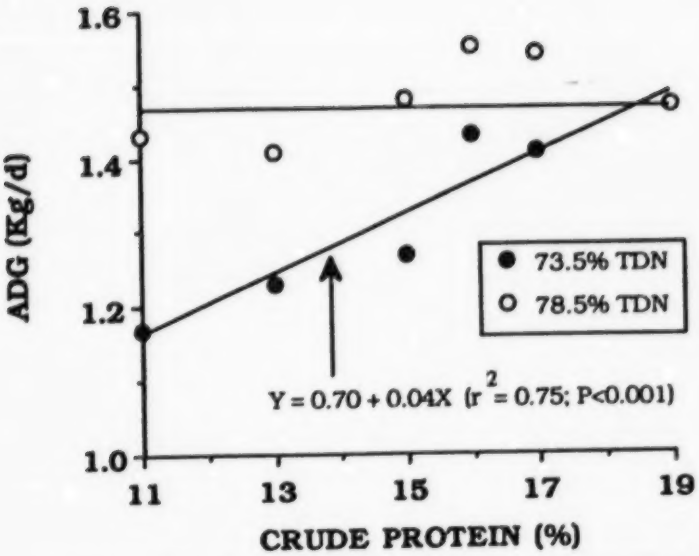

Figure 1. The effect of protein and energy on the average daily gain of large framed steers fed from weaning to slaughter.

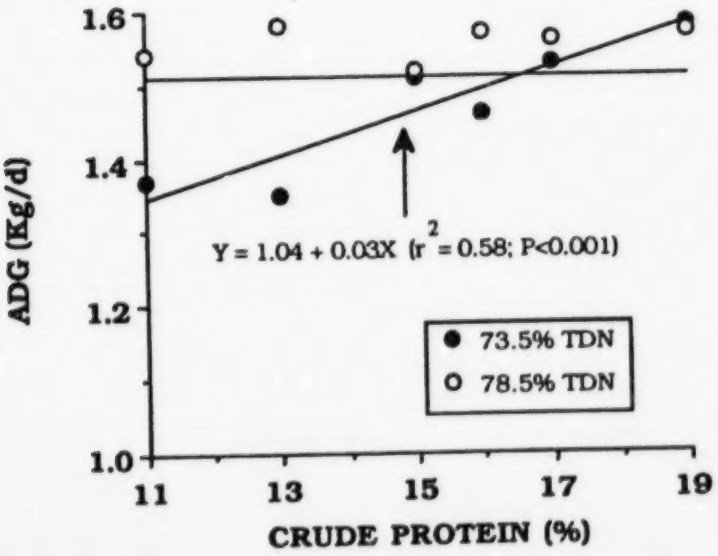

Figure 2. The effect of protein and energy on the average daily gain of backgrounded large framed steers.

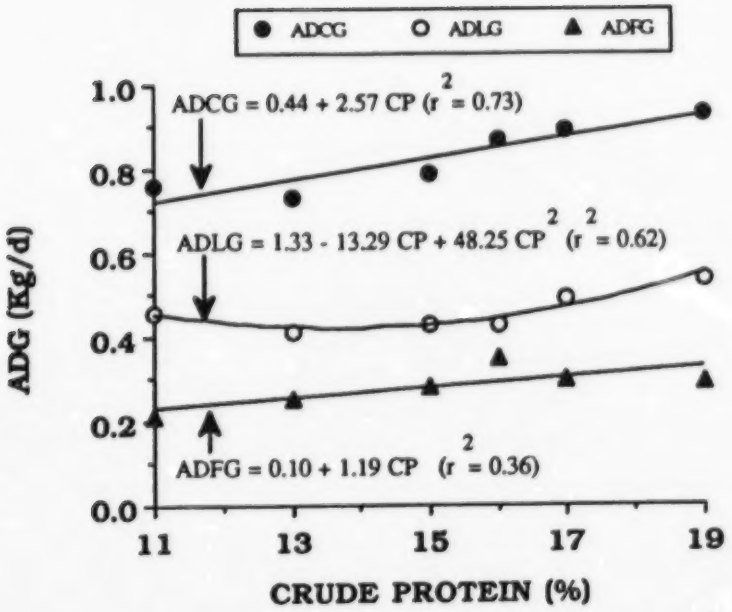

Figure 3. The effect of protein on the average daily gain of carcass (ADCG), lean (ADLG) and fat (ADFG) of large framed steers fed a 73.5% TDN ration from weaning to slaughter.

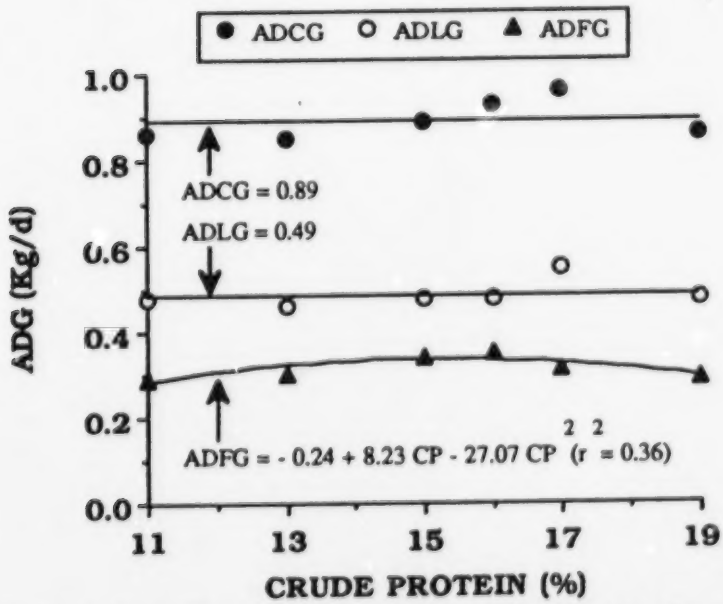

Figure 4. The effect of protein on the average daily gain of carcass (ADCG), lean (ADLG) and fat (ADFG) of large framed steers fed a 78.5% TDN ration from weaning to slaughter.

Table 1: Silage to concentrate ratios and chemical analysis of experimental rations used in trial 1 and 2.

	Low Energy						High Energy					
	Crude Protein Level (%)											
Parameter[1]	11	13	15	16	17	19	11	13	15	16	17	19
Silage %	42.3	46.2	42.2	40.2	38.2	34.2	15.0	22.3	18.4	16.4	14.4	10.4
Concentrate %	57.7	53.8	57.8	59.8	61.8	65.8	85.0	77.7	81.6	83.6	85.6	89.6
CHEMICAL COMPOSITION %												
Trial 1												
Dry matter	64.9	62.7	64.9	66.1	67.2	69.5	80.5	76.3	78.5	79.7	80.8	83.1
TDN[2]	73.5	73.5	73.5	73.5	73.5	73.5	78.5	78.5	78.5	78.5	78.5	78.5
Crude protein[3]	11.2	12.9	14.7	15.7	16.6	18.7	11.1	12.5	14.8	15.7	16.4	18.5
Calcium	1.0	0.8	0.9	0.9	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Phosphorus	0.5	0.5	0.5	0.6	0.6	0.6	0.4	0.4	0.5	0.5	0.6	0.6
Trial 2												
Dry matter	65.3	63.1	65.4	66.5	67.6	69.9	80.6	76.5	78.7	79.8	80.9	83.2
TDN[2]	73.5	73.5	73.5	73.5	73.5	73.5	78.5	78.5	78.5	78.5	78.5	78.5
Crude protein[3]	11.0	13.1	14.7	16.1	17.6	19.3	11.4	12.9	14.8	16.5	17.0	18.7
Calcium	0.7	0.8	0.8	0.9	0.8	1.0	0.8	0.8	0.8	0.9	0.8	0.9
Phosphorus	0.4	0.4	0.5	0.5	0.6	0.6	0.5	0.4	0.4	0.5	0.5	0.6

[1] Dry matter basis.
[2] Estimated.
[3] Crude protien values are averages of samples collected throughout the feeding period.

Table 2: Average as fed ingredient composition of concentrate mixes used in trial 1 and 2.

	Low Energy						High Energy					
	Crude Protein Level (%)											
Parameter[1]	11	13	15	16	17	19	11	13	15	16	17	19
Barley	90.6	77.4	65.7	58.1	50.6	45.0	93.0	87.1	78.7	71.8	68.0	61.0
Canola	0.0	13.0	24.4	32.1	40.4	46.3	0.0	5.5	14.1	21.3	25.3	32.4
Tallow	5.4	5.8	6.0	5.7	5.5	5.1	3.6	4.0	3.9	3.8	3.7	3.5
TM Salt[2]	0.8	1.0	1.0	0.9	0.9	0.8	0.6	0.7	0.6	0.6	0.6	0.7
Limestone	2.2	1.8	1.9	1.8	1.6	1.8	1.8	1.7	1.7	1.5	1.4	1.4
Vitamin premix[3]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

[1] Actual ingredient levels varied slightly depending upon nutrient analysis of ration ingredients fed throughout the feeding period.
[2] Minimum 5025 mg/kg zinc, 413 mg/kg iodine, 188 mg/kg iron, 8025 mg/kg manganese, 3000 mg/kg copper and 100 mg/kg colbalt.
[3] 4400 IU vitamin A and 880 IU vitamin D per kg.

Table 3. The influence of dietary crude protein and energy level on performance of large frame steer calves placed directly in the feedlot following weaning.

Parameter[1]	Crude Protein Level %							TDN %		
	11	13	15	16	17	19	SEM[2]	73.5	78.5	SEM
FEEDLOT PERFORMANCE										
Start wt (kg)	316.70	318.10	315.60	315.40	311.10	315.40	1.56	317.70	313.10	1.11
Finish wt (kg)	491.70	493.30	494.10	502.90	506.40	492.40	7.81	499.90	493.70	5.51
Days on feed	140.60	132.70	133.00	128.00	135.00	124.00	3.69	140.00[a]	125.00[b]	2.61
DAILY GAIN (kg)										
Day 0-70	1.30[a]	1.38[ab]	1.42[ab]	1.54[b]	1.53[ab]	1.51[ab]	0.04	1.37[a]	1.53[b]	0.03
Day 0-Finish	1.30[a]	1.32[a]	1.38[ab]	1.49[b]	1.48[b]	1.47[b]	0.03	1.33[a]	1.48[b]	0.02
DRY MATTER COSUMPTION (kg)										
Day 0-70	7.47	7.83	8.04	8.45	8.24	8.27	0.22	8.10	8.00	0.16
Day 0-Finish	7.62	7.77	8.04	8.49	8.32	8.28	0.24	8.13	8.05	0.17
FEED EFFICIENCY[3]										
Day 0-70	5.81	5.69	5.68	5.50	5.44	5.49	0.20	5.95[a]	5.25[b]	0.14
Day 0-Finish	6.13	5.87	6.00	5.81	5.79	5.83	0.19	6.25[a]	5.56[b]	0.14

[1] means in the same row with different superscripts are significantly different ($P < 0.05$).
[2] SEM = standard error of the mean.
[3] kg of dry matter per kg of gain.

Table 4. The influence of dietary crude protein and energy level on carcass characteristics of large frame steer calves placed directly in the feedlot following weaning.

	Crude Protein Level %							TDN %		
Parameter[1]	11	13	15	16	17	19	SEM[2]	73.5	78.5	SEM
Carcass wt (kg)	279.20	277.40	278.40	281.50	285.50	276.60	4.40	281.30	278.20	3.11
Dressing %	57.20	56.70	56.90	56.40	56.70	56.50	0.19	56.80	56.60	0.14
Ribeye area (cm^2)	81.60	79.40	78.10	79.80	80.80	78.10	1.30	81.10[a]	78.20[b]	0.92
Cutability (%)	61.40	61.10	60.60	61.00	60.70	60.10	0.28	61.50[a]	60.20[b]	0.20
Grade Fat (mm)	6.60	6.80	7.00	7.00	7.30	7.40	0.21	6.50[a]	7.50[b]	0.15
Marbling[3]	6.80	7.20	6.80	7.00	6.90	7.30	0.10	6.90[a]	7.10[b]	0.07

[1] means in the same row with different superscripts are significantly different ($P < 0.05$).
[2] SEM = standard error of the mean.
[3] score 1 = excessive marbling; 5 = medium marbling; 10 = devoid of marbling;

Table 5. The influence of dietary crude protein and energy level on carcass composition of large frame steer calves placed directly in the feedlot following weaning.

Parameter[1]	Crude Protein Level %							TDN %		
	11	13	15	16	17	19	SEM[2]	73.5	78.5	SEM
INITIAL CARCASS COMPOSITION (kg)										
Weight	170.30	169.30	167.50	168.70	167.80	171.30	2.09	169.80	168.50	1.48
Lean	114.30	113.70	112.40	113.20	112.60	114.90	1.40	113.90	113.10	0.99
Fat	21.90	21.80	21.60	21.70	21.60	22.00	0.27	21.90	21.70	0.19
Bone	34.20	34.00	33.60	33.80	33.60	34.30	0.42	34.00	33.80	0.30
FINAL CARCASS COMPOSITION (kg)										
Weight	286.42	268.64	275.65	275.60	288.36	286.56	7.38	282.70	277.72	4.26
Lean	181.90	168.80	171.20	167.50	181.00	181.00	4.78	177.40	173.10	3.38
Fat	57.10	55.90	60.30	63.00	61.00	58.40	1.44	58.90	59.70	1.02
Bone	47.40	43.90	44.20	45.10	46.40	47.10	1.39	46.40	44.90	0.98
TOTAL CARCASS GAIN (kg)										
Weight	116.09	99.03	107.51	106.90	121.60	114.91	7.61	112.78	109.24	4.39
Lean	67.60	55.20	58.80	54.30	68.40	66.20	4.90	63.40	60.00	3.46
Fat	35.20	34.10	38.70	41.20	39.40	36.30	1.35	37.01	38.00	0.95
Bone	13.20	9.90	10.60	11.30	12.70	12.74	1.44	12.41	11.10	1.02
AVERAGE DAILY CARCASS GAIN (kg)										
Weight	0.81^{ab}	0.79^{a}	0.84^{ab}	0.90^{ab}	0.92^{b}	0.90^{ab}	0.03	0.83^{a}	0.89^{b}	0.01
Lean	0.47	0.44	0.46	0.45	0.51	0.51	0.02	0.46	0.49	0.02
Fat	0.25^{a}	0.27^{ab}	0.31^{ab}	0.35^{b}	0.31^{ab}	0.29^{ab}	0.01	0.28^{a}	0.31^{b}	0.01
Bone	0.09	0.08	0.08	0.09	0.09	0.10	0.01	0.09	0.09	0.01

[1] means in the same row with different superscripts are significantly different ($P < 0.05$).

[2] SEM = standard error of the mean.

Table 6. The influence of dietary crude protein and energy level on performance of large frame steers backgrounded over the winter, prior to placement in the feedlot.

	Crude Protein Level %							TDN %		
Parameter	11	13	15	16	17	19	SEM[1]	73.5	78.5	SEM
FEEDLOT PERFORMANCE										
Start wt (kg)	358.80	360.50	363.00	361.3	354.80	360.30	2.03	354.30	365.20	1.63
Finish wt (kg)	563.20	541.10	545.70	536.10	537.10	542.00	5.37	539.80	548.70	3.80
Days on feed	128.00	111.00	110.00	106.00	110.00	108.00	3.93	115.00	109.00	2.78
DAILY GAIN (kg)										
Day 0-70	1.96	1.71	2.02	1.93	1.95	2.01	0.06	1.94	2.00	0.04
Day 0-Finish	1.46	1.47	1.51	1.52	1.54	1.57	0.04	1.46	1.56	0.03
DRY MATTER CONSUMPTION (kg)										
Day 0-70	10.03	10.19	10.79	10.77	10.62	11.13	0.34	10.58	10.60	0.24
Day 0-Finish	10.13	10.31	10.67	10.63	10.51	10.77	0.36	10.64	10.37	0.26
FEED EFFICIENCY[2]										
Day 0-70	5.11	5.30	5.36	5.60	5.51	5.53	0.21	5.46	5.34	0.15
Day 0-Finish	6.33	6.33	6.40	6.39	6.32	6.40	0.25	6.53	6.19	0.18

[1] SEM = standard error of the mean.
[2] kg of dry matter per kg of gain.

Table 7. The influence of dietary crude protein and energy level on carcass characteristics of frame steers backgrounded over the winter, prior to placement in the feedlot.

	Crude Protein Level %							TDN %		
Parameter	11	13	15	16	17	19	SEM[1]	73.5	78.5	SEM
Carcass wt (kg)	315.80	306.30	308.30	305.20	305.70	309.80	4.01	305.40	311.60	2.84
Dressing %	57.00	57.30	57.20	57.60	57.30	57.70	0.25	57.30	57.40	0.17
Ribeye area (cm^2)	83.90	82.10	82.30	81.30	83.50	82.60	1.90	82.10	83.10	1.34
Cutability (%)	61.50	60.70	61.00	60.20	60.60	60.60	0.41	60.90	60.70	0.29
Grade Fat (mm)	7.10	7.80	7.50	8.50	8.60	8.30	0.40	7.70	8.30	0.28
Marbling[2]	6.90	6.60	6.50	6.70	6.60	6.70	0.11	6.60	6.80	0.08

[1] SEM = standard error of the mean.
[2] Score 1 = excessive marbling; 5 = medium marbling; 10 = devoid of marbling;

Table 8. The influence of dietary crude protein and energy level on carcass composition of large frame steers backgrounded over the winter prior to placement in the feedlot.

	Crude Protein Level %							% TDN		
Parameter	11	13	15	16	17	19	SEM[1]	73.5	78.5	SEM
INITIAL CARCASS COMPOSITION (kg)										
Weight	189.00	195.90	193.80	194.10	186.20	188.00	1.39	187.00	195.30	0.98
Lean	126.90	131.40	130.00	130.20	124.90	126.20	0.93	125.50	131.10	0.66
Fat	24.30	25.20	24.90	25.00	24.00	24.20	0.18	24.10	25.10	0.13
Bone	37.90	39.30	38.90	38.90	37.30	37.70	0.28	37.50	39.20	0.20
FINAL CARCASS COMPOSITION (kg)										
Weight	312.16	315.99	306.41	308.94	307.85	307.91	6.74	304.60	315.20	3.89
Lean	194.40	195.20	187.00	190.80	190.00	190.00	5.28	189.50	192.90	3.73
Fat	64.40	68.90	69.20	67.00	66.90	65.90	1.62	64.40	69.70	1.14
Bone	53.40	51.90	50.20	51.10	51.10	52.10	1.15	50.70	52.60	0.81
TOTAL CARCASS GAIN (KG)										
Weight	123.14	120.13	112.65	114.88	121.69	119.93	6.18	117.56	119.92	3.57
Lean	67.50	63.80	57.00	60.60	65.00	63.70	5.04	64.00	61.90	3.56
Fat	40.10	43.70	44.30	42.00	42.90	41.70	1.60	40.40	44.60	1.13
Bone	15.50	12.60	11.30	12.20	13.70	14.40	1.08	13.20	13.40	0.76
AVERAGE DAILY CARCASS GAIN (KG)										
Weight	0.97	1.05	1.06	1.06	1.05	1.08	0.05	1.02	1.07	0.03
Lean	0.52	0.56	0.53	0.55	0.56	0.57	0.03	0.55	0.55	0.02
Fat	0.32	0.38	0.42	0.40	0.37	0.38	0.02	0.36	0.40	0.02
Bone	0.12	0.11	0.11	0.12	0.12	0.13	0.01	0.11	0.12	0.01

[1] SEM = standard error of the mean.

Table 9. Influence of heat and chemical treatment on apparent insitu rumen digestion of canola meal[1].

Canola Meal Treatment[2]	Dry Matter Disappearance %	Crude Protein Disappearance %	ADIN[4]
Untreated	57.80[a]	59.64[a]	0.32
Heat Treatment			
125° C - 10 min	38.92[b]	27.69[b]	0.56
125° C - 20 min	35.79[c]	22.08[c]	0.55
125° C - 30 min	35.57[c]	22.71[c]	0.58
145° C - 10 min	28.47[d]	14.07[d]	2.34
145° C - 20 min	27.02[d]	15.68[d]	2.35
145° C - 30 min	26.84[d]	14.45[d]	2.49
Chemical Treatment			
Acetic Acid	57.93[a]	59.79[a]	0.29
Formic Acid	58.92[a]	63.80[a]	0.29
SEM[3]	0.71	0.98	

[1]Dry matter and crude protein disappearance measured after 12 hr of rumen incubation.
[2]Means within columns with different superscripts differ significantly ($P < 0.05$).
[3]SEM = standard error of the mean.
[4]ADIN = acid detergent insoluble nitrogen (%).

Table 10. The silage to concentrate ratio and chemical analysis of complete mixed rations fed in trial 4.

	13 % Crude Protein				16 % Crude Protein			
	Bypass Protein Level %				Bypass Protein Level %			
Parameter[1]	22	28	32	34	22	28	32	34
Silage %	27.0	26.8	26.8	30.8	22.1	20.7	20.5	26.0
Concentrate %	73.0	73.2	73.2	69.2	77.9	79.3	79.5	74.0
Chemical Analysis								
Dry matter	60.6	60.7	60.7	57.9	64.4	65.6	65.8	61.3
TDN[2]	73.5	73.5	73.5	73.5	73.5	73.5	73.5	73.5
Crude protein[3]	13.1	13.3	13.4	13.2	16.1	16.2	16.3	16.1
Calcium	0.8	0.8	0.7	0.8	0.9	0.9	0.7	0.8
Phosphorus	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4

[1] Dry matter basis.
[2] estimated.
[3] Crude protein values are averages of samples taken through out the trial.

Table 11. The ingedient composition of concentrate mixes used in Trial 4.

Ingredient[1]	13 % Crude Protein				16 % Crude Protein			
	Bypass Protein Level %				Bypass Protein Level %			
	22	28	32	34	22	28	32	34
Barley	77.0	67.7	67.6	71.3	68.6	57.4	56.0	59.0
Straw	13.7	13.4	13.5	14.0	12.7	12.4	12.4	13.1
Tallow	4.1	4.1	4.1	4.3	3.9	3.8	3.8	4.0
Urea	1.2	0.0	0.0	0.0	1.5	0.2	0.0	0.0
Canola meal	0.0	11.2	0.0	0.0	9.8	23.0	13.3	14.4
Heated canola meal	0.0	0.0	11.2	0.0	0.0	0.0	11.2	0.0
Corn gluten meal	0.0	0.0	0.0	6.2	0.0	0.0	0.0	5.9
1:1 mineral	0.4	0.0	0.0	0.6	0.0	0.0	0.0	0.0
Limestone	1.8	1.8	1.8	1.8	1.7	1.4	1.5	1.8
TM salt[2]	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Vitamin premix[3]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

[1] As fed.
[2] Minimum 5025 mg/kg zinc, 413 mg/kg iodine, 188 mg/kg iron, 8025 mg/kg manganese, 3000 mg/kg copper and 100 mg/kg colbalt.
[3] 4400 IU vitamin A and 880 IU vitamin D per kg.

Table 12. The influence of dietary crude protein and bypass protein level on performance of large frame steers placed directly in the feedlot following weaning.

Parameter[1]	Bypass Protein Level %					Crude Protein %		
	22	28	32	34	SEM[2]	13	16	SEM
FEEDLOT PERFORMANCE								
Start wt (kg)	319.20	316.30	319.70	319.00	1.41	318.90	318.10	1.00
Final wt (kg)	499.10	512.30	507.60	508.80	4.50	507.00	507.10	3.70
Days on feed	142.50	147.70	146.30	149.90	2.42	149.50[a]	143.80[b]	1.71
DAILY GAIN (kg)								
Day 0 to 56	1.19[a]	1.32[b]	1.26[ab]	1.21[ab]	0.03	1.21[a]	1.28[b]	0.02
Day 0 to Finish	1.28	1.33	1.31	1.29	0.03	1.27[a]	1.34[b]	0.02
FEED CONSUMPTION (kg)								
Day 0 to 56	8.22	8.27	8.03	8.10	0.20	8.10	8.21	0.14
Day 0 to Finish	8.83	8.85	8.58	8.75	0.20	8.69	8.81	0.15
FEED EFFICIENCY								
Day 0 to 56	6.95	6.27	6.38	6.71	0.18	6.73	6.43	0.12
Day 0 to Finish	6.98	6.67	6.69	6.89	0.14	6.91	6.70	0.10

[1] means in the same row with different superscripts are significantly different ($P < 0.05$).
[2] Standard error of the mean.

Table 13. The influence of dietary crude protein and bypass protein level on performance of large large frame steers placed directly in the feedlot following weaning.

	Bypass Protein Level %					% Crude Protein		
Parameter	22	28	32	34	SEM[1]	13	16	SEM
Carcass wt (kg)	281.2	289.7	285.3	287.5	2.53	284.7	287.2	1.79
Dressing %	56.9	57.2	57.0	57.1	0.23	56.9	57.2	0.16
Ribeye area (cm^2)	80.5	82.4	80.6	82.9	1.23	80.5	82.7	0.87
Cutability (%)	61.3	61.3	61.1	61.6	0.33	61.4	61.3	0.24
Grade fat (mm)	7.0	7.1	6.9	7.0	0.22	6.8	7.2	0.15
Marbling score[3]	6.9[ab]	7.1[a]	6.7[b]	7.0[ab]	0.08	6.9	7.0	0.06

[1] means in the same row with different superscripts are significantly different ($P < 0.05$).
[2] Standard error of the mean
[3] Score 1 = excessive marbling; 5 = medium marbling; 10 = devoid of marbling;

Table 14. The influence of supplemental crude protein on profit potential of large frame steer calves fed low energy rations.

Parameter[1]	% Crude Protein					
	11	13	15	16	17	19
Canola cost[2] ($/hds/trial)	0.00	19.33	40.96	55.60	68.45	81.40
Barley cost ($/hd/trial)	69.70	50.39	49.35	45.60	39.32	34.85
Silage cost ($/hd/trial)	46.91	46.50	46.30	44.58	40.99	35.52
Total feed cost[3] ($/hd/trial)	116.66	116.22	136.61	145.78	148.76	151.77
Live animal value ($/hd/trial)	919.20	924.00	929.50	958.70	944.40	945.20
Net return ($/hd/trial)	NA	5.20	-9.70	10.33	-6.95	-9.17

[1]Based on canola prices at $200.00 per tonne, barley at $103.00 per tonne and live cattle price of $1.87 per kg.

[2] Canola intake adjusted to account for variation in barley crude protein content utilized through out the trial.

[3] Total feed cost = Barley cost + Silage cost + Canola meal cost.